Applying of Lean Manufacturing Concepts to Improve Process Flow in a Needlework Industry

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Abstract *— The needlework industry is one of the oldest and most important industries for the economy of many countries. In Puerto Rico it is a source of jobs since 1940 for many regions as: Lares, Las Marias, Cabo Rojo, Camuy, Arecibo, Mayaguez and Añasco. Currently, it is unstable and constantly decreasing. Unlike other industries it cannot replace the ability of its employees by the evolution of technology. Improved process flow through the implementation of Lean Manufacturing can help conserve the needlework industries. Lean Manufacturing is a methodology that eliminates waste, which is defined as activities that do not add value to a product. Lean Manufacturing is derived from the Japanese manufacturing industry and can be used in any industries.*

Key Terms *— Lean Manufacturing, Needlework Industry, Standardized Work Flow, Waste.*

PROBLEM STATEMENT

Research Description

Sewing modules make requisition to an area called Preparation Area anytime they want to start a production. The Preparation Area is not organized in a way that can supply the demand from manufacturing. A lot is made of fabric and different types of materials such as binding tape, hook and loop. The lots are travel throughout the plant back and forward several times in order to be completed. Both the fabric and materials has to visit the Marking Area which is approximately 100 feet away. Currently this process takes a lot of time causing errors and inefficiency.

Research Objectives

The objective of this project is to develop a process improvement flow to reduce waiting times and unnecessary transport. The same time getting better quality and service to the Production Area. After completing this project the transportation times should be reduced at least 20%.

Research Contributions

The contributions of this project will include:

- Eliminate unnecessary transport;
- Reduce Costs;
- Increase Production; and
- Increase Efficiency.

LITERATURE REVIEW

Historical Background

Over the years the needlework industry has an economic impact in Puerto Rico. Needlework [3] define the needlework industry as the work performed by using a needle, plain sewing, mending, or ornamental work such as embroidery. There are different machines focuses in the type of stitch we want to create. Eliminating waste by using Lean Manufacturing may help to conserve the employments of many Puerto Ricans and give an opportunity to develop more businesses.

The purpose of Lean Manufacturing is to impact the productivity and quality of all organizations. [6] It originated in Japan after the World War II, with the help of Edward Deming and Taiichi Ohno, Shigeo Shingo and, Eijy Toyoda. They founded the concept emulating the Toyota Production System, who later served as a model for United States (U.S.) manufacturing firms. [2] Lean

Manufacturing was developed to address their specific needs in a restricted market in times of economic trouble. It is a set of several tools, which seek to eliminate all operations that do not add value to the product or service and that will only add time and money.

According with "Escuela de Organization Industrial" [1] the eight tools of Lean Manufacturing are explained in ***Figure 1***.

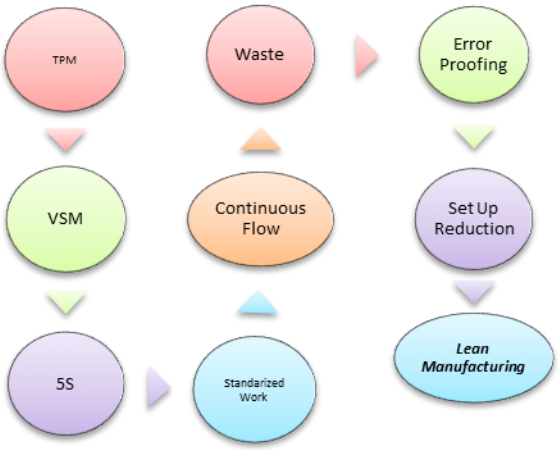


Figure 1
Tools of Lean Manufacturing

Tool 1: Value Stream Mapping or VSM

The Value Stream Map is a diagram with all the activities in a business that are required to design and produce a product and deliver it to the customer. It is a tool that helps us to see and understand the flow of material and information about how a product is made. The VSM also helps us to identify the tasks that add value to the product and the tasks that are waste.

Tool 2: 5S

Rosario [1] definer the 5S tool as the name of an organization workplace that uses a list of five Japanese words. The words are listed and explain below:

1. Seiri - Sort

Involves reviewing all elements of the workplace and remove what is not necessary.

2. Seiton - Organize

Involves putting all the necessary elements in place, facilitating their location.

3. Seiso - Cleaning

Involves cleaning every day to keep clean, inspect the workplace and equipment for possible defects.

4. Seiketsu - Standardize

Involves creating visual controls and guidelines to keep the place organized, neat and clean.

5. Shitsuke - Discipline

Involves maintaining a training and discipline to ensure that every one follow the rules of 5 S.

Tool 3: Standardized Work

Standardized work provides a clear and complete instruction for the operator. Three necessary components in standard work are:

1. Takt time

Tack Time is the time required to make a piece according to the customer demand. It is calculated with the following equation (1):

$$TT=\frac{Available\ Time}{Demand} \quad (1)$$

2. Work Sequence

Cyger [4] establish the Work Sequence the order in which an operator performs manual operations (including walking and waiting). It is extremely important to determine the best and most efficient way for operators to perform their work. It helps ensure your process maintains consistency and stability. Whenever possible our aim should be to limit wasted motion, reaching, or any other non-value added action.

Tool 4: Types of Waste

Philbrick [5] mention that in order to improve any process, one should eliminate the following wastes:

1. Overproduction
2. Processing
3. Transportation
4. Defects / Quality
5. Inventory

6. Waiting
7. Motion
8. Unused Resources

Tool 5: Total Productive Maintenance (TPM)

TPM is a methodology that ensures fast and continuous improvement in manufacturing by eliminating equipment damage. This methodology relied on the following activities:

- Predictive Maintenance
- Preventive Maintenance
- Corrective Maintenance

Tool 6: Error Proofing

Error Proofing is a process improvement created to prevent a specific defect that may occur.

Tool 7: Set up Reduction

Set up Reduction is a method to analyze and significantly reduce the change-over time. To perform this step with efficiency it is necessary to identify the internal and external activities.

- Internal Activities
  Activities performed while the machine is stopped.
- External Activities
  Activities performed while the machine is producing.

Tool 8: Continuous Flow

Continuous Flow is a manufacturing system designed to pull back production.

An effective system will be:

- Producing what the customer demands
- Provides a visual control of the production system
- Easy to see if the production has advanced or decreased
- Eliminates the continuous reevaluation of the needs of production and this results in real increase in productivity

Needlework Industry Environment

The Preparation Area is responsible for having everything prepared before being required by the manufacturing area. They prepare their work using lots, and are divided per style. The lots contain all the materials they need to produce the quantity specified in the batch headers. The batch headers are printed documents that contains all the materials needed to produce a specifically quantity of a product. They are printed as soon as the orders come in. Lots are made of fabric and different types of materials. The fabric is cut in a laser machine following the patterns provided by the designer. The materials are binding tape, hooks, loops, coordura webbings, and nylons of different lengths.

Both the fabric and materials have to pass through the marking area. The preparation area is 55 feet away of marking room and the cutting area is 162 feet away. See ***Figure 2*** the preparation area dimensions are 66 feet x 82 feet and marking room area is 1,200 square feet. The cutting Area is 9,200 square feet. After the lots are marked they return to Preparation Area to catch out with the materials not need marking. Finally, a lot is ready for production area. This procedure has a lot of travel time having the consequences of lacking materials and/or adding other materials in a specific lot.

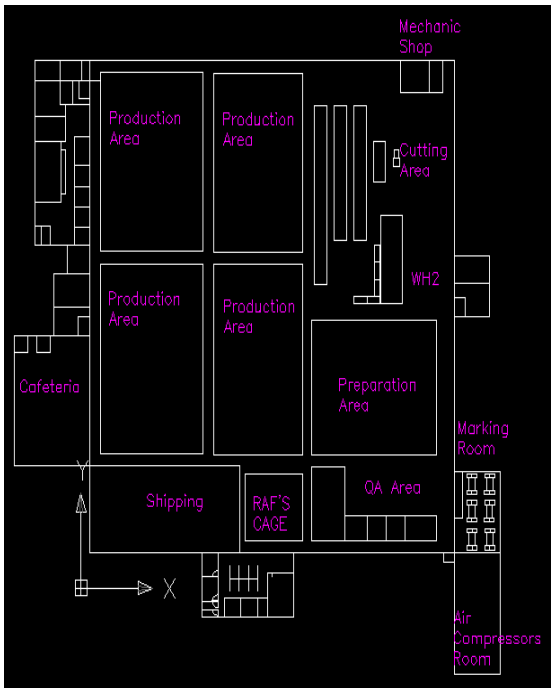


Figure 2
Needlework Industry Layout

METHODOLOGY

In order to achieve the goals previously established it is necessary to use a DMAIC Methodology to develop an organized roeadplan. DMAIC is an abbreviation for the five steps to development a Lean-Six Sigma project. The abbreviation words are defined as Define, Measure, Analyze, Improve, and Control. ***Figure 3*** shows the DMAIC cycle. This methodology is not exclusive for Six Sigma and can be applied in many other projects.

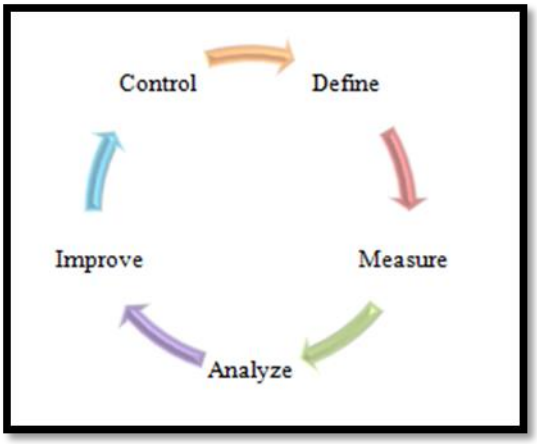


Figure 3
DMAIC Cycle

I. **Define Phase** – This phase is responsible for defining the client and their requirements and expectations. These customer requirements are called CTQ (Critical to Quality). Also at this stage the project scope needs to be determined.
   a. Develop a process flow –is a type of diagram that shows the steps needed to complete a specific job.

II. **Measure Phase** – The purpose of this phase is to measure the current performance of the process. In this step it is necessary to collect data.
   a. Identify potential issues with process flow
   b. Specify and evaluate metrics

III. **Analyze Phase** – The intention of this phase is to analyze the data collected and to identify ideas that eliminate waste and make the process more effiicient.
   a. Analyze 8 types of waste

IV. **Improve Phase** – The objective of this phase is to identify solutions that are easiest to implement in the process.
   a. Desing a new layout
   b. Desing new Work Instructions

V. **Control Phase** – The importance of this phase is to continuously monitoring and verifying process improvements to sustain the results obtained.
   a. Supervisors and Management must perform a weekly audit to ensure the process establish per engineering is being executed in a right way.

RESULTS AND DISCUSSION

This section discusses the activities performance for the research project following the DMAIC methodology.

Define Phase – The define phase established the following:

a. Client – In the case in study the clients are internal. An internal client are defined as a co-employees. The employees of Production Area are the clients of the employees of the preparation Area.
b. Expectations of the Client – Production Area wants to have complete lots. The lots must have good quality and be ready on time.
c. Project Scope – The scope of this project is to change the actual location of the Preparation Area in order to relayout the process of making lots to achieve the expectations of the client. ***Figure 4*** shows a detailed project scope statement Product Scope Description, Project Deliveries, Project Assumptions, Project Exclusions and, Project Acceptance Criteria.
d. Process Flow – describes all the process needed to complete a lot for a X product see ***Figure 5***.

	Project Scope Statement
	Project Name: Applying of Lean Manufacturing Concepts to Improve Process Flow in a Needlework Industry
Project Deliverables	Develop new service for Manufacturing Area.
Project Assumptions	The delivery time to development the project is 3 months.
Project Exclusions	The project does not have Exclusions.
Product Acceptance Criteria	Customer satisfaction

Figure 4
Detailed Project Scope

Measure Phase – In this phase it is necessary to collect data.

a. Identify potential issues with process flow – Per history data an average of 27% of the lots arrive incomplete to the Production Area. Fabric and Materials are lost in the process. This problem cause waist of time and efficiency in Production Area. To eliminate this problem is necesarry to change the order of the process and the decision if the lot it is ready or not must be determined before lots are in production area.

b. Specify and evaluate metrics – **Table *1*** shows the distance and the time consume to move fabric and materials to the Marking Room. This is the actual data of the current process.

Table 1
Current Data of the Process

	Distance (Feet)	Time (Minutes)
Cutting Area – Marking Room	162	2.35
Preparation Area – Marking Room	74	.88

Analyze Phase – The intention of this phase is to analyze the data collected.

a. ***Analyze 8 types of waste*** – As previous mentioned in chapter 2 there are 8 types of possible waste:

1. Overproduction
2. Processing
3. Transportation
4. Defects / Quality
5. Inventory
6. Waiting
7. Motion
8. Unused Resources

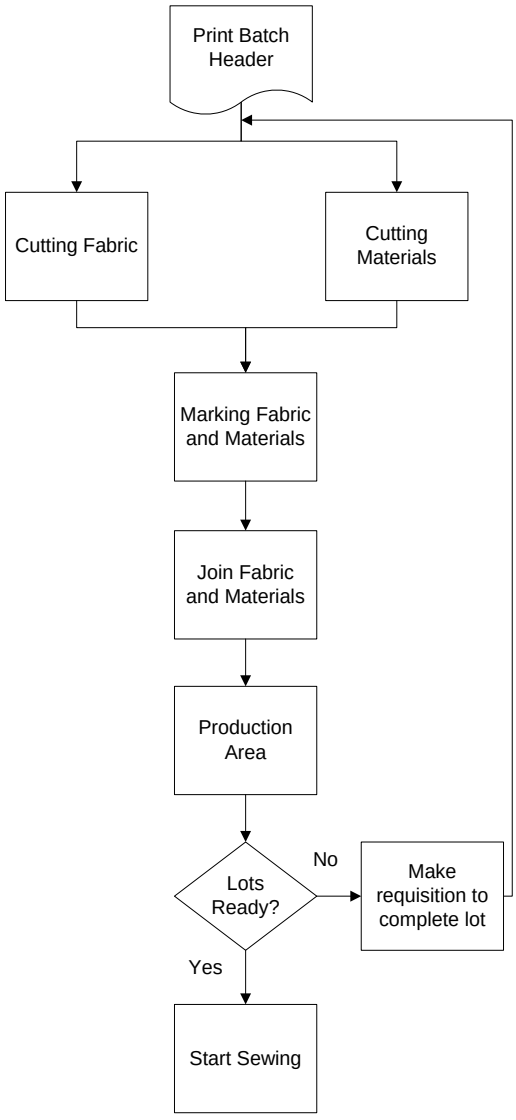


Figure 5
Preparation Process for Product X

Analyzing the collected data the following wastes are identified: Transportation and Motion.

- **Transportation Waste** is the material movement that is not directly associated with a value adding process. There is a large distance between the Preparation Area and the Cutting Area (162 feet) The excess of transportation is caused by the poor layout. As a resolution the process must be as close together as possible and material flow directly from process to process without delay.
- **Motion Waste** is any motion of man or equipment that does not add value to the product. The most popular example of this waste is walking without working. All the marking operators walk to cutting area to look for work several times a day.The average time of this travel is 2.35 minutes in one way including all the interruptions the operators find in their travel. The average number of travels is 16 per shift per operator. They are 12 operators in Marking Room.

Using this data the average percentage of time that the operators are walking through the plant without job was calculated.

Operators Time Traveling = 12 x 16 x (2.35 x 2)

= 902. 40 minutes

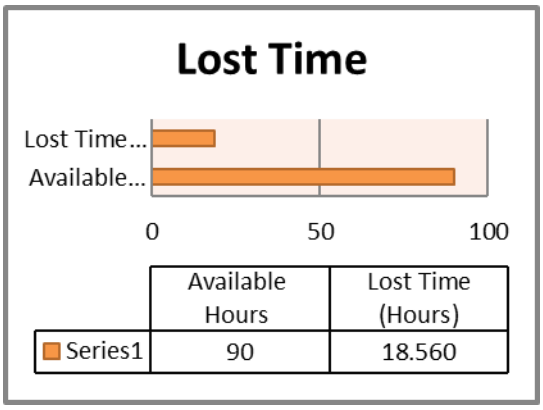
This is the equivalent of 5.44 hours of labor of 1 operator. On the other hand these operators are walking .88 minutes to Preparation Area in an average of 10 times per shift.

Operators Time Traveling = 12 x 10 x (.88 x 2)

= 211.2 minutes

The net time lost walking through the plant is (902.4 minutes + 211.4 minutes) 1113.6 minutes. ***Table 2*** shows a representation of the lost time.

Table 2
Process Lost Time



Improve Phase – The objective of this phase is to identify solutions.

a. Desing a new layout – To eliminate the lost time identified in the previous phase it is necessary to relocate the marking area.

This new layout proposition in ***Figure 6*** consists of moving the mechanic shop to an actual Marking Room and relocates the Marking Room right next to Cutting Area. The mechanic will have an easy access station in the production floor in order to reduce their lost time too. Also the preparation Area is 21 feet closer.

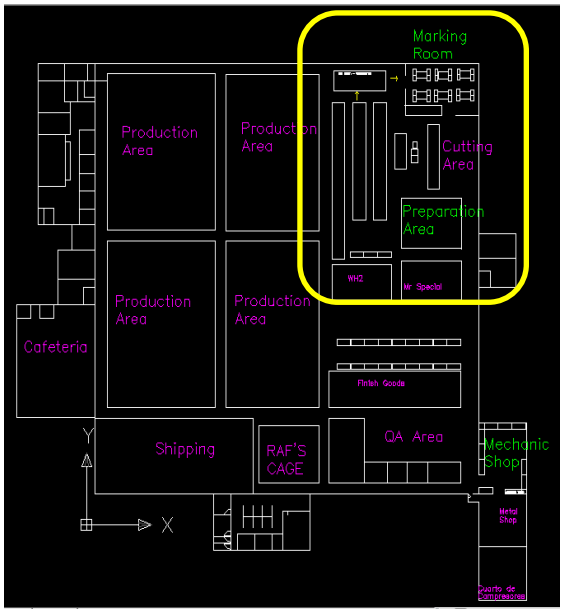


Figure 6
New Layout for Marking Room

b. Desing Work Instructions – It is important to change the way that employees collect their work materials. The work instructions for employees of Marking Room will change as follows:

1. Operators of Cutting Area must cut and placed the materials in a rack. When the rack is ready for Marking Room only one operator of Marking Area seek for materials. This will reduce travels in order that one trip must be equal to 8 old trips. The operator performance this operation will have the posion of Runner.
2. Other employees in their Marking Area should remain in their workstations.
3. Also the runner must looks for work in the preparation Area. The operators for preparation Area also need to put their materials in a Rack.

Table 3
Process New Data

	New Distance (Feet)	New Time (Minutes)
Cutting Area – Marking Room	38	.68
Preparation Area – Marking Room	53	.64

After making these two improvements new data for distance and time to transport the materials from one station to another was obtained.

Table 3 shows the data for the change proposal.

Following the previous instructions were calculated the new times for transportation.The time that the runner should be looking materials is as follows:

Runner Time = 24 x (.68 x 2)x 1 =32.64 minutes

Runner Time = 2 x (.64 x 2) x 1 = 2.56 minutes

Runner Net Time =35.20 minutes

Definitely, the change in the layout of Marking Room is the fastest and most accurate way to reduce transportation time and unnecessary movements of employees. The time spent with actual layout is 1113.6 minutes. The time spent with proposal layout will be 35.20 minutes. These improvements will give us the savings explain below:

- Difference in time is 1078.4 minutes, the equivalent to 17.97 hours which means that the company saving more than the salary of 2 employees per shift. It is necessary to relocate employees in order to be more efficiency.
- Currently, the plant only has one shift so the savings must be at least $7.25/hour x 17.97 hours equals to $130.28 daily. The annual saving is $32,570.63.

Control Phase – The importance of this phase is to continuous monitoring and verifying process. ***Table 4*** shows the audit sheet to monitoring the contol phase.

Table 4
Audit Sheet for Control Phase

Audit Sheet for Marking Room		
	Yes	**No**
All operators are in their workstations		
Only the runner is seek for materials		
The racks are with enough materials		

CONCLUSION AND RECOMMENDATIONS

This research validates that using the tools of lean manufacturing can help conserve the needlework industry. Based on the results, identifying and eliminating waste not only improve quality and costs it also help to get better performed to understanding of the process.

The objectives and contributions of the research were reached giving the company the opportunity to be more competitive. Also give the company the opportunity to be more efficient and have an organized process work flow.

After implementing this project it is recommended to do a 5S project in order to create a place for everything and to have everything in its

place so that everyone continues using the tools of Lean Manufacturing.

REFERENCES

[1] Rosario, N. M., *Escuela de Organizacion Industrial*, December 18, 2011 Retrieved from http://www.eoi.es/blogs/nayellymercedeslazala/2011/12/18/lean-manufacturing-y-sus-herramientas/.

[2] Manotas Duque, D., & Cadavid, L. "Lean Manufacturing Measurement: The Relationship Between Lean Activities And Lean Metrics". *Estudios Gerenciales*, *23*(105), 2007 pp. 69-83.

[3] Needlework, *Columbia Electronic Encyclopedia, 6th Edition*, 2013.

[4] Cyger, M., *Isixsigma*. May, 2000. Retrieved from http://www.isixsigma.com/dictionary/standard-work/.

[5] Philbrick, H. *Slideshare*. December, 2008. Retrieved from http://www.slideshare.net/Harbrick/8-wastes-presentation.

[6] Padilla, L., "Lean Manufacturing", *Revista Ingenieria Primero*, January, 2010, pp. 64-69.